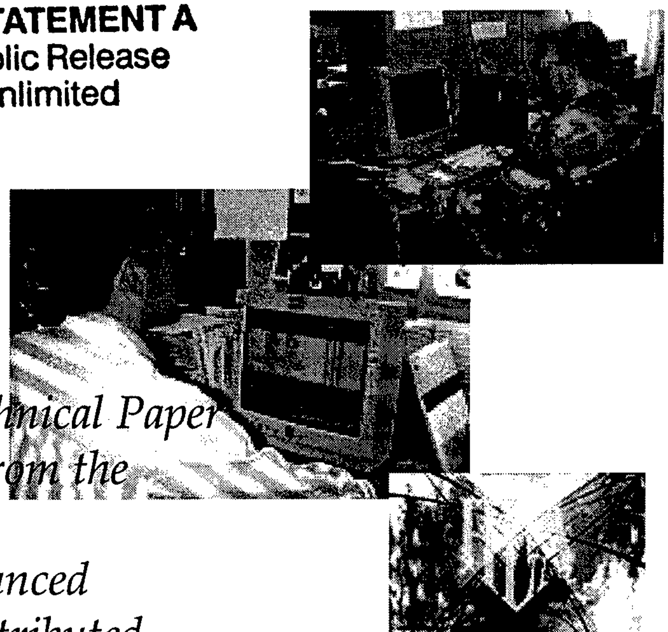
Determining and Expressing Runtime Infrastructure Requirements



A Technical Paper from the Joint Advanced Distributed Simulation Joint Test Force

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Abstract: The Joint Advanced Distributed Simulation (JADS) Joint Test Force (JTF) is chartered by Office of the Secretary of Defense to investigate the utility of Advanced Distributed Simulation (ADS) Technology to Test and Evaluation (T&E). JADS is executing three test programs (C4I, Precision Guided Munitions, and Electronic Warfare) representing slices of the overall T&E spectrum as well as observing other activity within the T&E community to form its conclusions. One of the slices, the Electronic Warfare test, is using HLA. This paper discusses process and products used by JADS to identify system requirements, including the requirements allocated to the RTI, and communicate those RTI requirements to DMSO.

1. Introduction

Building a federation is an application of a system engineering process to achieve the users objective. One of the cornerstones of system engineering is the ability to allocate system requirements down to components. Another requirement is to be able to articulate component requirements to suppliers. The focus of this paper is the process JADS used to allocate system requirements to the RTI and how those requirements were articulated to DMSO. This is the companion paper to 98S-SIW-152 which discusses how JADS intends to verify RTI and network performance.

2. Background

JADS is an OSD sponsored Joint Test Force chartered to determine the utility of Advanced Distributed Simulation (ADS) technology for Test and Evaluation (T&E) of military systems. JADS is doing this by looking at three slices of the T&E spectrum. One of those slices is the JADS EW Self Protection Jammer test. This test will use two HLA compliant federations to recreate an actual Open Air Range (OAR) test to see how the results using the federations correlate with the OAR results.

The OAR test represents an effectiveness test of an airborne self protection jammer. One referent test condition will be repeated to gather a large sample of jammer effectiveness data. The environment, the threat systems, and the jammer are all instrumented to allow standard measures of performance to be calculated and to allow the engagements to be recreated in the federations. Each OAR test event will be recreated, the federate interactions will be monitored, and the measures of performance will be calculated in real-time

3. Requirements Definition Process

The requirements definition process that we used came from a solid understanding of the interactions between aircraft carrying self protection jammers and surface to air threat systems. The process was also driven by a lack of understanding of object oriented design methods and a lack of understanding of the functionality and performance the RTI could bring to the simulation. The problem space was defined by the referent test

condition used in the OAR test. As the referent test condition was refined, the problem space had to be reviewed to verify that the federation design was still valid.

The top level design was accomplished during a test concept review. The participants took the test concept and identified all the relevant objects that appeared in the scenario. In this case, objects were easy to identify since there are only a few physical entities that interact in the test scenario. The result was a fairly flat class structure. The participants also identified all the attributes of interest and all the interactions between objects. This initial work was then placed on hold while the referent test condition was refined.

The next phase of the design focused on the interactions and on the work previously accomplished by the Engineering Protofederation (EPF). Two of the facilities, ACETEF and AFEWES, used in the EPF are being used in the JADS federation. Our intent was to sensibly capture pertinent attributes and interaction definitions and message structures used by the EPF. This represented the maximum reuse that we could expect and allowed us to use the EPF facility interfaces as starting points for designing the interfaces for JADS. This phase of the design was accomplished over three technical interchange meetings. The result was a spreadsheet that listed all the objects, their attributes, and their interactions. Structured attributes were created where they made sense. Definitions were created or identified from DIS to ensure the team understood what each attribute and interaction meant. The spreadsheet also identified the number of bits allocated to each attribute and interaction and the frequency each needed to be updated. The spreadsheet became our conceptual model of the federation.

The third phase focused on determining how much latency the jammer/threat interaction could tolerate and still be valid. There are two valid interactions that can be modeled, each requiring a different latency. The first is the jammer computer to threat computer. The second is the jammer computer to human operator. The latency is driven by the decision cycle times of the jammer computer and either the threat computer or the threat operator. The jammer used in the JADS test is simple and has a very short decision cycle. Likewise the threat computers have very short decision cycles. The analysis showed that it was unrealistic to model the computer to computer interaction. The latency expected from linking AFEWES in Ft Worth TX and ACETEF in Patuxant River, MD was too great to faithfully reproduce the engagements that normally occur at distances shorter than 50 km. In fact, the analysis indicated that once the widearea communications time, the local area network communications time, and the facility interface processing times for both AFEWES and ACETEF were accounted for, the acceptable latency for the RTI had to be negative. We dropped the computer to computer interaction and opted for the second approach. The decision cycle time for the threat operator was estimated to be 500 ms, an achievable latency objective. Once the total latency was identified, the 500 ms were allocated to the communications infrastructure, facility interfaces and the RTI.

The latest review of the requirements occurred in October when the results of the first OAR practice mission were reviewed and adjustments made to the conceptual model. The conceptual model has been used to generate the Federation Object Model, determine and adjust the network topology, and fill out the DMSO Federation Planner's Workbook. Figure 1 is an excerpt from the conceptual model listing the key assumptions. This is provided to give the reader a feeling for the problem space JADS is examining.

# of Threats	4	
# of Targets	1	
Run Duration (Single test event)	600	sec
# of Technique Assigns/run/threat	10	
# of Threat Mode Changes/run/threat	10	
# of Simultaneous RF Signals	20	
# of Signals Tracked by SUT	12	
SUT Instrumentation Reporting Rate	5	Hz
Network Health Check Update Rate	1	Hz
TSPI Update Rate	20	Hz

Tracking Data Update Rate	20	Hz
C3 Track Update Rate	1	Hz
# of extraneous RF Changes/run	10	
# of Missiles/run/threat	20	
# of Missiles in the Air	6	
# of semi-active Missiles in the Air	1	

Figure 1 Key Design Assumptions

4. Allocation of Requirements

The following is a summary of the requirements derived for the JADS EW test. These requirements are only for the JADS EW test and in no way represent the requirements of other performance based federations or the requirements for Test and Evaluation sponsored federations.

Performance Measure	JADS Requirement
Attribute/interaction Size	Max: 672 bits Min: 16 Bits
Update Frequency	Max: 20 Hz Min: 1 Hz
Expected bandwidth	Max: 183335 bits per second
Time to Create New Objects	10 milliseconds
CPU Utilization	RTI: 25% Overhead: 5%
Allowable RTI latency	< 300 milliseconds for closed loop interaction

Figure 2 Summary of RTI Requirments

5. Communication of Requirements to RTI Developers

The primary tool for communicating requirements to the RTI development community is the Federation Planner's Workbook. JADS began working with DMSO to articulate our perceived requirements for RTI performance in May 97. I use the term perceived, because, while we could articulate what performance we wanted out of the federation, we weren't sure what aspects of performance were critical from an RTI builders perspective. Our first attempt was to create a system specification to describe RTI/network performance. DMSO's counterproposal was to use the first generation of RTI performance workbooks which were Excel spreadsheets being designed for users of federations to communicate different aspects of RTI performance requirements. We completed these and have subsequently worked through two other versions of DMSO tools. The latest version are the Federation Planners Workbook.

While it remains to be seen how well the tools facilitate the communication between RTI developers and federation developers, we have found the tools to be extremely useful in creating the JADS EW Federation Object Model. We constantly refered to the Federation Planner's Workbook, our own concept model spreadsheets, and our interface control document. The FOM development became another cross check of the different design representations prior to federate development and integration.

6. Conclusion

Throughout the process of developing and articulating our requirements, we have raised questions and provided comments to improve not only the product but the level of understanding on both the RTI developer's and on the federation developer's sides. There is still work that needs to be done. For example, one of the critical aspects of RTI performance seems to be the amount of computing resources available for it to use. Yet articulating this requires the developer to quantify the tick rate without necessarily understanding the timing implications to the simulation and to overall performance of the federate.

One final caution. The performance that JADS has identified for our federation should not be interpreted to be the level of performance that future test efforts will require. The purpose of JADS is to determine the utility of ADS technology for Test and Evaluation. Our intent was to approach reasonably close to edge of the performance envelope of ADS. The CROSSBOW sponsored Threat Simulator Linking Activity developed a network specification addressing the requirements for future ADS based EW testing and concluded that the tolerable latency for operating mode data (changes in either threat radar or jammer state) is 50 to 100 milliseconds with a goal of 3 milliseconds. As we try to develop such closely coupled systems, we will need to find ways for developers to unambiguously articulate system performance requirements and RTI suppliers to unambiguously articulate actual system performance. These two issues will become critical as we migrate towards commercial and custom developed RTIs.